Stoller
Hanford Office
established 1959

299-W18-173 (A7655)
Log Data Report

Borehole Information:

Borehole:	299-W18-173 (A7655)		Site:	216-Z-1A Crib	
Coordinates (WA St Plane)		GWL[1] (ft) :	None	GWL Date:	04/03/07
North (m)	East (m)	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
135440.7	566554.641	10/77	676.92	51	Cable

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Welded Steel	2.15	8 5/8	8	5/16	2.15	51

Borehole Notes:

This borehole is being scheduled for decommissioning. Even though a swab of the borehole acquired prior to logging indicated no internal contamination, the analysis of the log data suggests internal, fixed alpha contamination. Caution should be exercised during decommissioning to prevent contamination of equipment and personnel.

The logging engineer measured the casing stick-up and diameter using a caliper and steel tape. Logging data acquisition is referenced to the TOC. According to the driller's log, contamination was encountered from 15 to 46 ft.

Logging Equipment Information:

Logging System:	Gamma 4N		Type:	SGLS (60%) SN: 45-TP22010A
Effective Calibration Date:	02/14/07	Calibration Reference:	HGLP-CC-009	
		Logging Procedure:	HGLP-MAN-002, Rev. 0	

Logging System:	Gamma 4H/with source		Type:	NMLS SN: H310700352
Effective Calibration Date:	11/22/06	Calibration Reference:	HGLP-CC-002	
		Logging Procedure:	HGLP-MAN-002, Rev. 0	

Logging System:	Gamma 4H/without source		Type:	PNLS SN: H310700352
Effective Calibration Date:	11/22/06	Calibration Reference:	HGLP-CC-002	
		Logging Procedure:	HGLP-MAN-002, Rev. 0	

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2	3 Repeat	4 Repeat	
Date	04/04/07	04/04/07	04/05/07	04/05/07	
Logging Engineer	Spatz	Spatz	Spatz	Spatz	
Start Depth (ft)	46.0	42.0	32.0	46.0	
Finish Depth (ft)	2.0	31.0	28.0	46.0	
Count Time (sec)	100	800	800	800	
Live/Real	R	R	R	R	
Shield (Y/N)	N	N	N	N	
MSA Interval (ft)	1.0	1.0	1.0	1.0	
ft/min	N/A[3]	N/A	N/A	N/A	

Log Run	1	2	3 Repeat	4 Repeat	
Pre-Verification	DN671CAB	DN671CAB	DN681CAB	DN681CAB	
Start File	DN671000	DN671045	DN681000	DN681005	
Finish File	DN671044	DN671056	DN681004	DN681005	
Post-Verification	DN671CAA	DN671CAA	DN681CAA	DN681CAA	
Depth Return Error (in.)	0	0	N/A	N/A	
Comments	No fine-gain adjustment.	Fine-gain adjustment after file -054.	No fine-gain adjustment.	No fine-gain adjustment.	

Neutron Moisture Logging System (NMLS) Log Run Information:

Log Run	5	6 Repeat			
Date	04/05/07	04/05/07			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	47.0	18.0			
Finish Depth (ft)	2.0	8.0			
Count Time (sec)	15	15			
Live/Real	R	R			
Shield (Y/N)	N	N			
Sample Interval (ft)	0.25	0.25			
ft/min	N/A	N/A			
Pre-Verification	DH482CAB	DH482CAB			
Start File	DH482000	DH482181			
Finish File	DH482180	DH482221			
Post-Verification	DH482CAA	DH482CAA			
Depth Return Error (in.)	0	0			
Comments	None	None			

Passive Neutron Logging System (PNLS) Log Run Information:

Log Run	7	8 Repeat			
Date	04/09/07	04/09/07			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	47.25	42.0			
Finish Depth (ft)	2.0	28.0			
Count Time (sec)	15	60			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	0.25	0.25			
ft/min	N/A	N/A			
Pre-Verification	DH492CAB	DH492CAB			
Start File	DH492000	DH492182			
Finish File	DH492181	DH492196			
Post-Verification	DH492CAA	DH492CAA			
Depth Error (in.)	- 0.5	- 0.5			
Comments	None	None			

Logging Operation Notes:

Logging was conducted with a centralizer on each sonde and measurements are referenced to TOC. Repeat data with the SGLS were acquired at a 800 second counting time from 28 to 42 ft to provide additional detail of the highest activity zone. Because the repeat data acquired at 800 seconds are statistically more reliable than data acquired at 100 seconds, the repeat data are plotted as the main logs.

The NMLS and PNLS data are acquired with the same sonde with an AmBe source and without, respectively.

Analysis Notes:

Analyst:	Henwood	Date:	04/18/07	Reference:	GJO-HGLP 1.6.3, Rev. 0

Pre-run and post-run verifications for the logging systems were performed before and after each day's data acquisition. The acceptance criteria were met.

A casing correction for 5/16-in.-thick casing was applied throughout the borehole for the SGLS.

SGLS spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated with an EXCEL worksheet template identified as G4NFeb07.xls using an efficiency function and corrections for casing and dead time as determined from annual calibrations. The NMLS count rate data were converted to volumetric moisture according to calibration data for a 8 in. borehole. The passive neutron logging system data are used for qualitative purposes and does not require a calibration.

Results and Interpretations:

^{137}Cs is detected at 3 and 5 ft at approximately 0.2 pCi/g.

^{237}Np is detected with the SGLS by measuring a daughter product (protactinium-233 (^{233}Pa)) that emits a prominent gamma ray at an energy of 312.17 keV. ^{233}Pa was detected from 9 to 46 ft. The maximum concentration is approximately 75 pCi/g at a 46 ft depth.

^{239}Pu was detected in this borehole. Gamma energy peaks normally used to quantify ^{239}Pu at 375.05 and 413.71 keV had interference from gamma rays at 376.65 keV (^{241}Am), 375.45 keV (^{233}Pa), 415.88 keV (^{241}Am), and 415.76 keV (^{233}Pa). After comparison of assays for each radionuclide using these energy peaks, it was determined the 413.71 keV gamma ray best represented the ^{239}Pu concentration. The approximate 414 keV energy peak was detected from 14 to 18 ft, from 28 to 42 ft, and at 46 ft. It was determined that only the interval from 14 to 18 ft actually represented ^{239}Pu. The 129.3 keV gamma ray originating from ^{239}Pu was observed in this interval. This energy peak is out of the calibration range for the SGLS (186 to 2615 keV). However, it provides corroborating evidence that ^{239}Pu exists. Where the 414 keV peak was detected in other intervals, it was determined the 415.76 keV gamma ray from ^{233}Pa was the dominant influence; the 129 keV gamma ray or other corroborating energy peaks were not observed. The maximum ^{239}Pu concentration was measured at 15 ft at approximately 36,000 pCi/g. It is possible internal contamination exists between 14 and 18 ft.

^{241}Am is detected from 28 to 42 ft and at 46 ft. The maximum concentration is measured at approximately 155,000 pCi/g at 30 ft. Gamma rays at 662, 722, and 60 keV were detected that represent ^{241}Am. ^{137}Cs emits a 661.66 gamma ray that cannot be distinguished from the 662.40 gamma ray emitted from ^{241}Am. A corroborating energy peak at 722.01 keV is used to establish the presence of ^{241}Am rather than ^{137}Cs. In this borehole the 722.01 keV energy peak is used to determine the ^{241}Am concentration. There appeared to be few or no residual counts in the 662 keV peak that could be attributed to ^{137}Cs.

The 60 keV energy peak was observed but it is not within the calibration range of the SGLS. In the interval from 14 to 18 ft, the 60 keV energy peak is detected in the absence of the 662.4 and 722.01 keV energy peaks. Although the yield of the 60 keV gamma is much greater than the 662 or 722 keV energy peaks (5 orders of magnitude), it is severely attenuated by the steel casing. Because the 60 keV energy peak is observed in the absence of the more energetic 662 and 722 keV energy peaks, it is postulated that internal contamination exists in this depth interval. Consequently, it is interpreted that no ^{241}Am exists in the sediments between 14 and 18 ft above an MDL of approximately 16,000 pCi/g.

An elevated ^{232}Th concentration as determined using the 2615 keV (^{208}Tl) energy peak, is indicated from 29 to 32 ft and at 25 ft. The plot of natural gamma logs shows the disruption of the equilibrium of the natural ^{232}Th decay, where the ^{228}Ac (911.20 keV) indicates ^{232}Th concentrations below that calculated from the ^{208}Tl (2615 keV) gamma line. This difference is attributed to the existence of ^{232}U. To determine the concentration of ^{232}U, the activity due to natural decay of ^{232}Th must be subtracted. The ^{228}Ac concentrations based on the 911.20 keV gamma line are subtracted from the ^{232}Th concentrations calculated based on the 2615 keV ^{208}Tl energy peak. The result is a concentration range from 0.1 to 0.3 pCi/g ^{232}U.

^{233}U almost certainly exists where ^{232}U is detected. In a reactor using thorium target material, ^{233}U will be generated at two to three orders of magnitude more than ^{232}U. However, at relatively low concentrations, ^{233}U does not emit a gamma ray that can be detected with the SGLS. Decay products that potentially could be measured, have not had sufficient time to grow into equilibrium with their parent so that detection is possible. It is inferred on the basis of the ^{232}U concentration that ^{233}U may exist at concentrations between 100 and 1000 pCi/g in this waste stream.

Passive neutron logging was performed in the borehole. This logging method has been shown to be effective in qualitatively detecting zones of alpha-emitting contaminants from secondary neutron flux generated by the (α,n) reaction and may indicate the presence of α-emitting nuclides, including transuranic radionuclides, even where no gamma emissions are available for detection above the MDL. The passive neutron signal depends on the concentration of α sources, and also the concentrations of lighter elements such as N, O, F, Mg, Al, and Si which emit neutrons after alpha capture. The passive neutron log indicated a maximum count rate of approximately 1.5 counts per second (cps) at 47 ft. Two intervals of slightly elevated count rates can be observed from 13 to 16 ft and from 28 to 39 ft. These count rates can be correlated with ^{241}Am, ^{239}Pu, or ^{237}Np contamination.

SGLS measurements at the bottom of the borehole (46 ft) indicate concentration increases. Soil sample results (Price et. al. 1979) indicated Pu at levels of 50,000 and 5,300 pCi/g, at 46 and 51 ft, respectively. The borehole may not have completely penetrated the contamination.

The naturally occurring radionuclides (KUT) and moisture data suggest the possibility of grout in the upper 12 ft of the borehole. Elevated moisture is observed at 4 and 13 ft. This could represent grout that was not uniformly emplaced around the borehole. Elevated moisture at the bottom of the borehole may also represent grout. It was a common practice in Z crib boreholes to seal the surface and place a “plug” in the bottom of the borehole. This is speculative but should be considered during decommissioning of the borehole.

A comparison plot of the 1993 and 1998 RLS (operated by Westinghouse Hanford Company and Waste Management Federal Services NW, respectively) spectral gamma data and 2007 SGLS data is included. There is generally good agreement in the assays for ^{237}Np and ^{239}Pu. However, there are differences in analysis and interpretation. For example, as discussed above, the SGLS analysis indicated the 413.71 keV ^{239}Pu energy peak measured below 18 ft to be dominantly the result of the 415.76 ^{237}Np gamma line. Good agreement is achieved by all three logging systems from 14 to 18 ft.

The assays for ^{241}Am are quite different and is believed to be the result of using different energy peaks for the assay. As discussed above, the current SGLS analysis uses the 722.01 keV energy peak to determine concentrations. It is believed the RLS analysis used the 60 keV energy peak. Severe attenuation by the steel casing of the 60 keV gamma ray could result in the significant underestimation of concentrations shown in the plot. Additionally, the current analysis postulates the ^{241}Am in the depth interval of 15 to 20 ft may be the result of internal casing contamination.

^{137}Cs (661.66 keV) is reported by the RLS analysis. It is believed the energy peak at approximately 662 keV was erroneously attributed to ^{137}Cs rather than to ^{241}Am (662.40 keV) that was determined in the current analysis. The current analysis agrees with ^{137}Cs concentrations reported near the 5 ft depth interval.

The current SGLS analysis suggests ^{232}U contamination from 29 to 32 ft. This possibility was not reported in the 1993 or 1998 RLS analysis.

Possible concentration increases in ^{237}Np are observed between 28 and 36 ft since 1993.

Part of the reason for differing measurements is the relative efficiency of the three detectors and counting times. Typically, the 1993 data were acquired with an 18 % efficient HPGe detector at 120 seconds and the 1998 data with a 35 % efficient HPGe at 90 seconds. The current SGLS logging was conducted with a 60 % efficient detector with

800 second counting times through the contaminated intervals. This increased efficiency and counting time significantly improves the detection limits, counting error, and the resulting analysis over the prior data.

The SGLS, NMLS, and PNLS repeat logs all show good repeatability.

List of Log Plots:

Depth Reference is TOC
Depth Scale - 20 ft/inch except for repeat logs

Manmade Radionuclides
Natural Gamma Logs
Combination Plot (20 ft/inch)
Combination Plot (10 ft/inch)
Total Gamma, Neutron Moisture, & Passive Neutron
SGLS/RLS Comparison of Manmade Radionuclides
Repeat of Manmade Radionuclides
Repeat for Neutron Moisture & Passive Neutron

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[1] GWL – groundwater level
[2] TOC – top of casing

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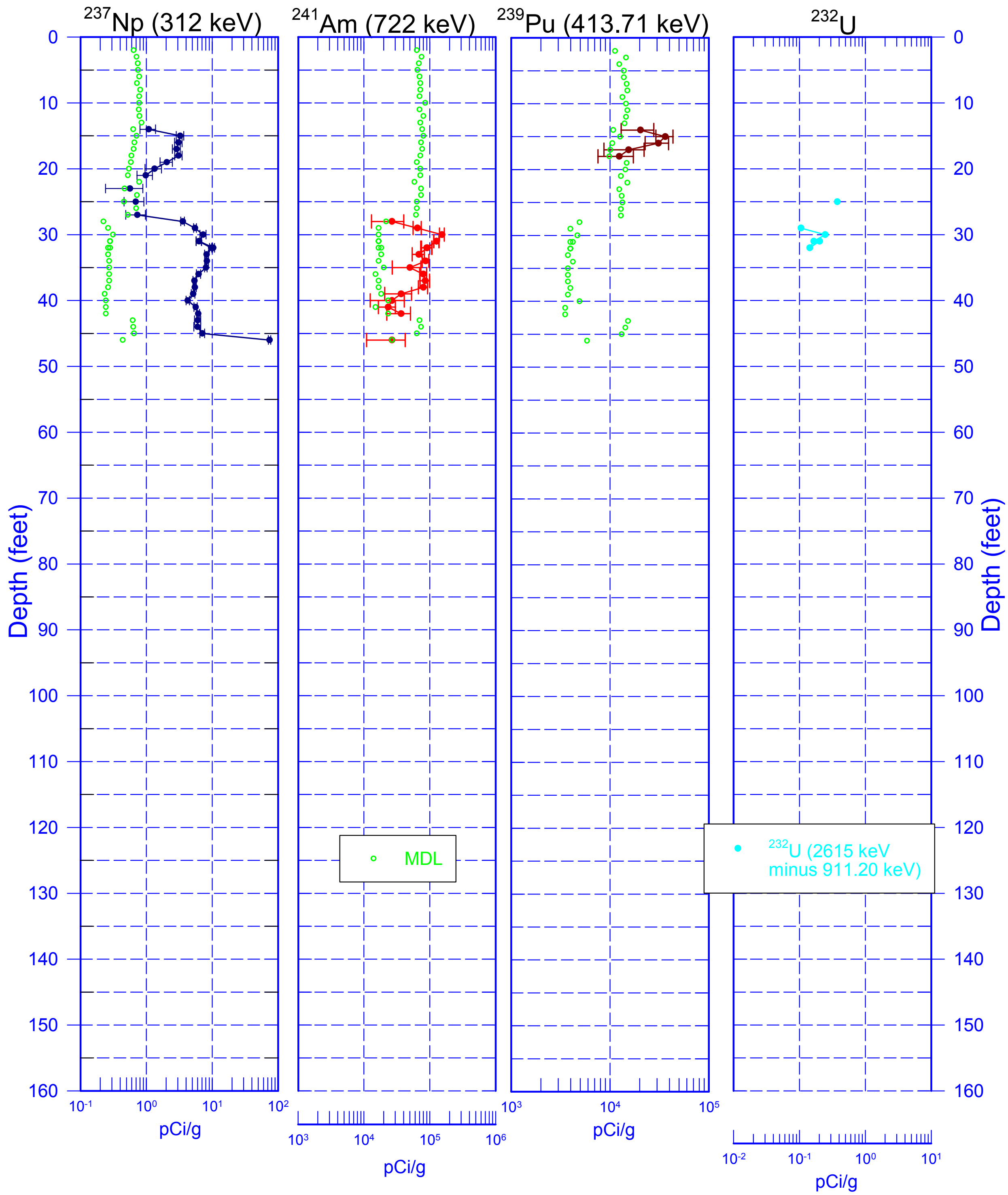
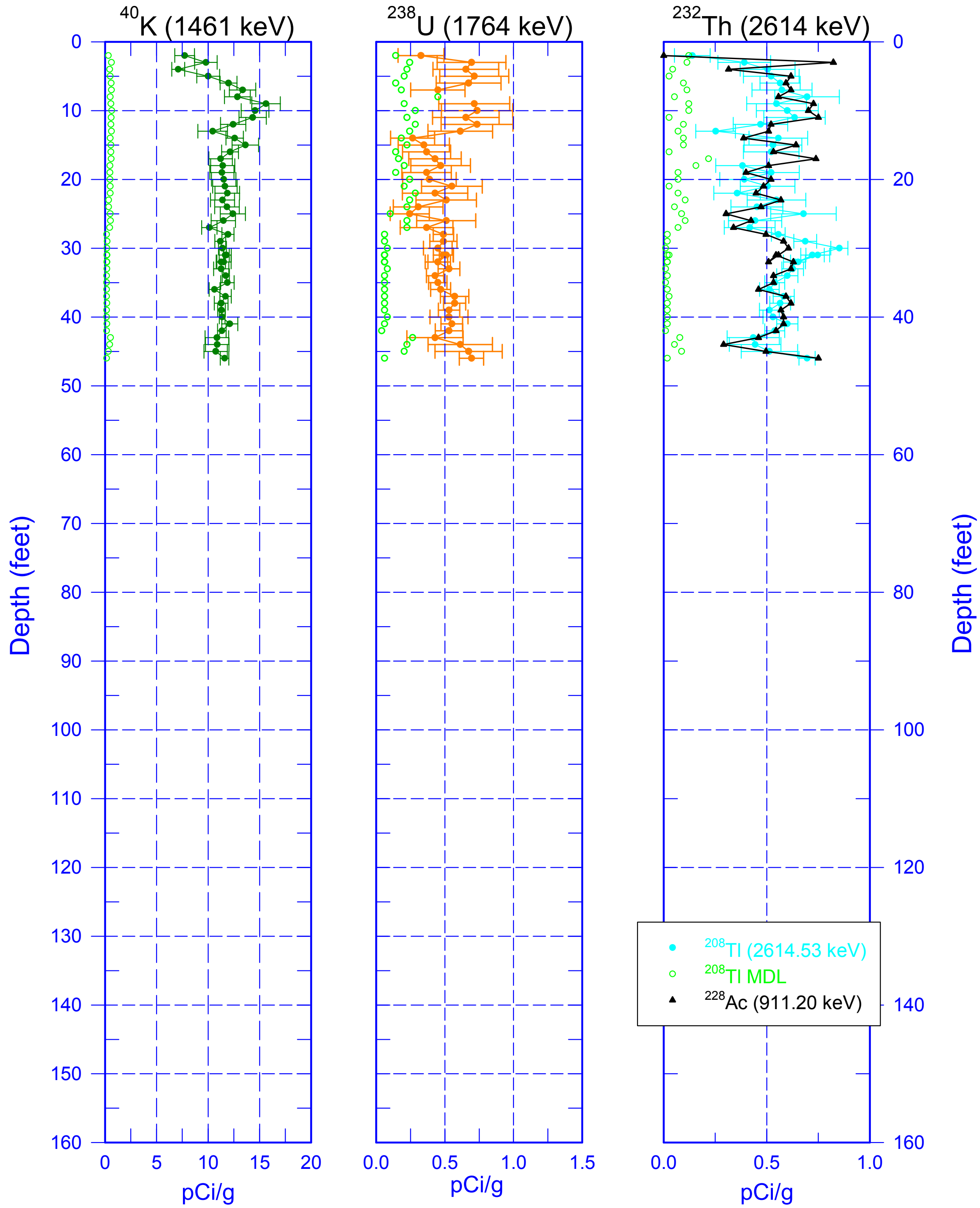
Manmade Radionuclides



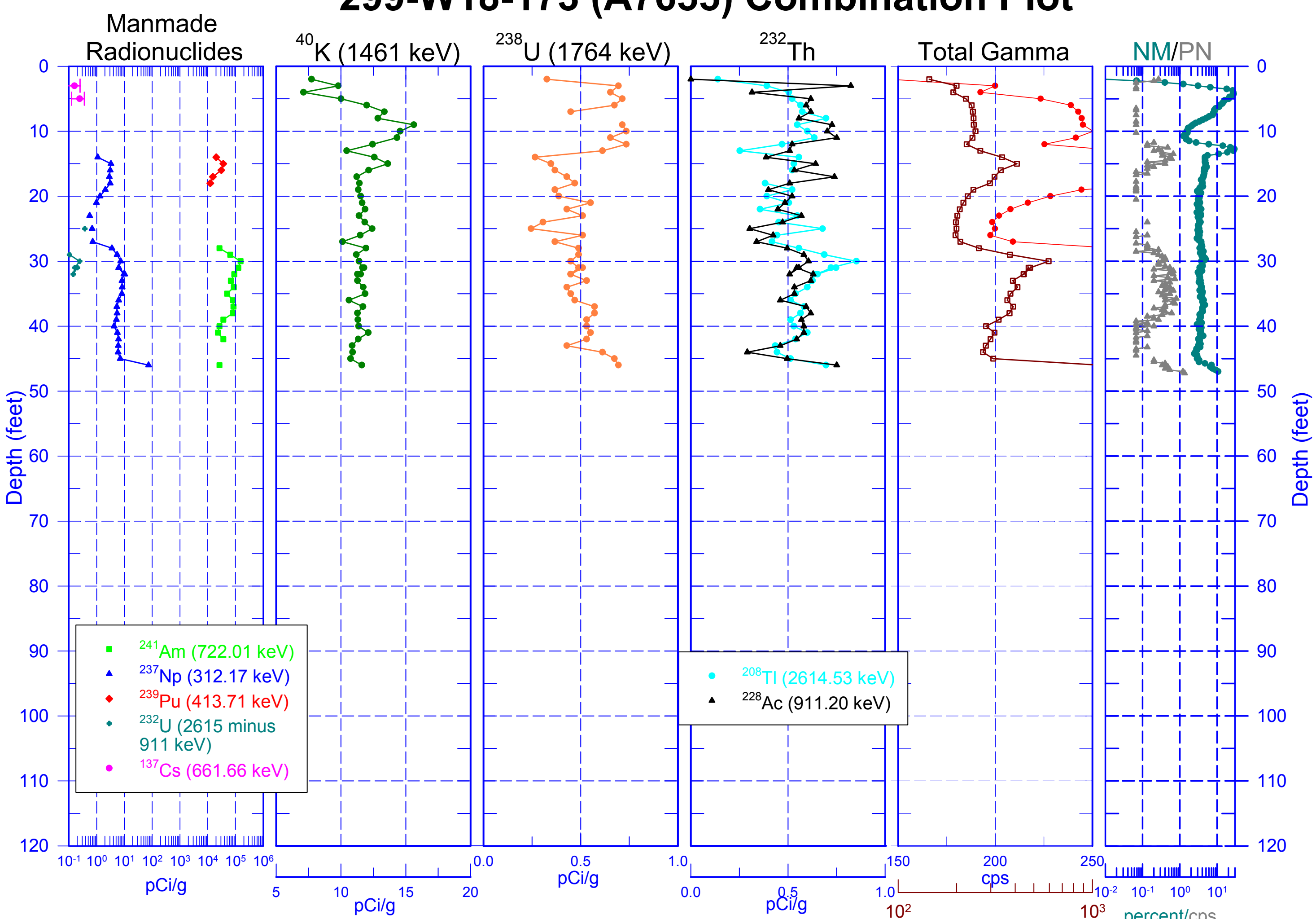
Zero Reference = Top of Casing

299-W18-173 (A7655)
Natural Gamma Logs



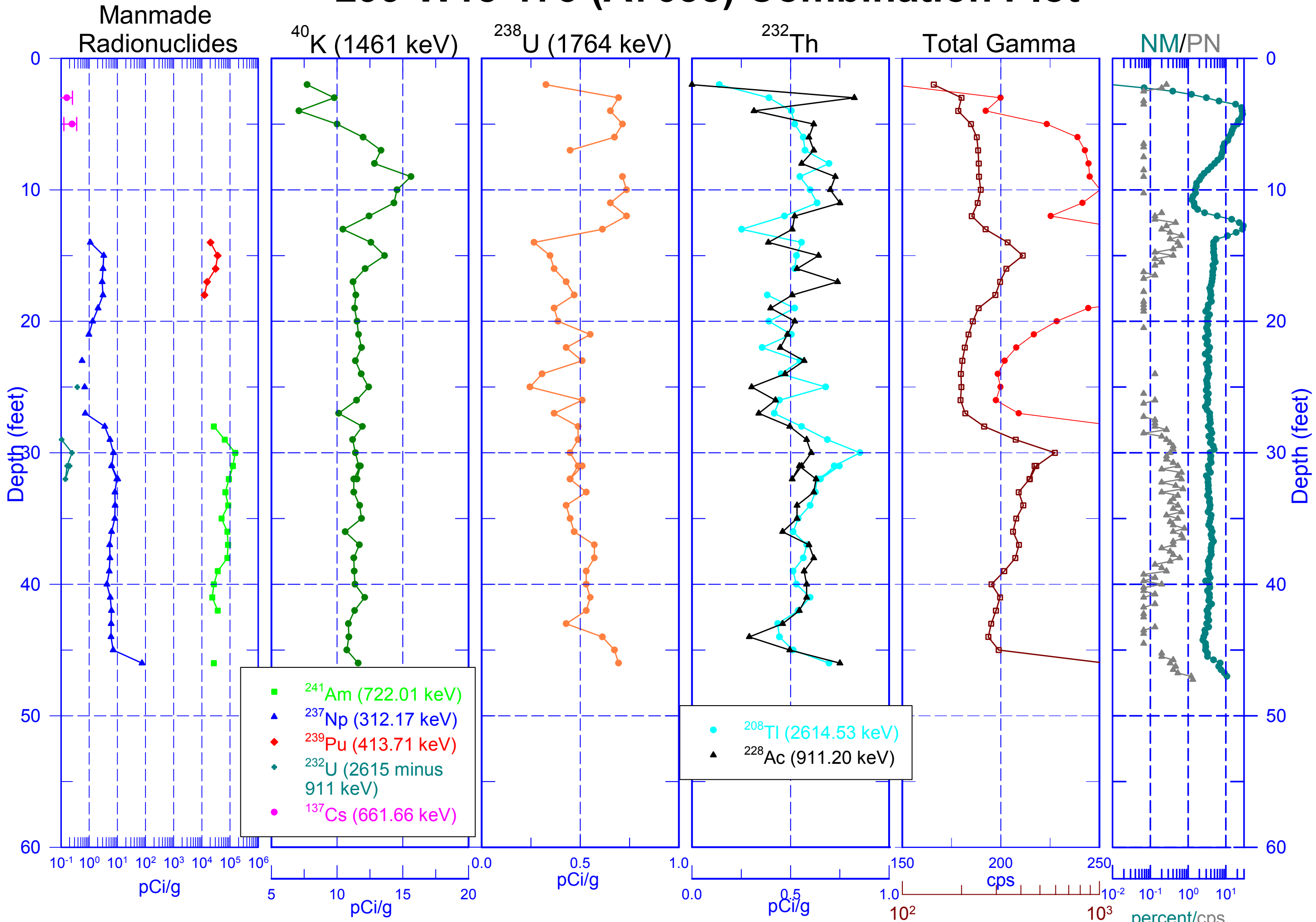
Zero Reference = Top of Casing

299-W18-173 (A7655) Combination Plot



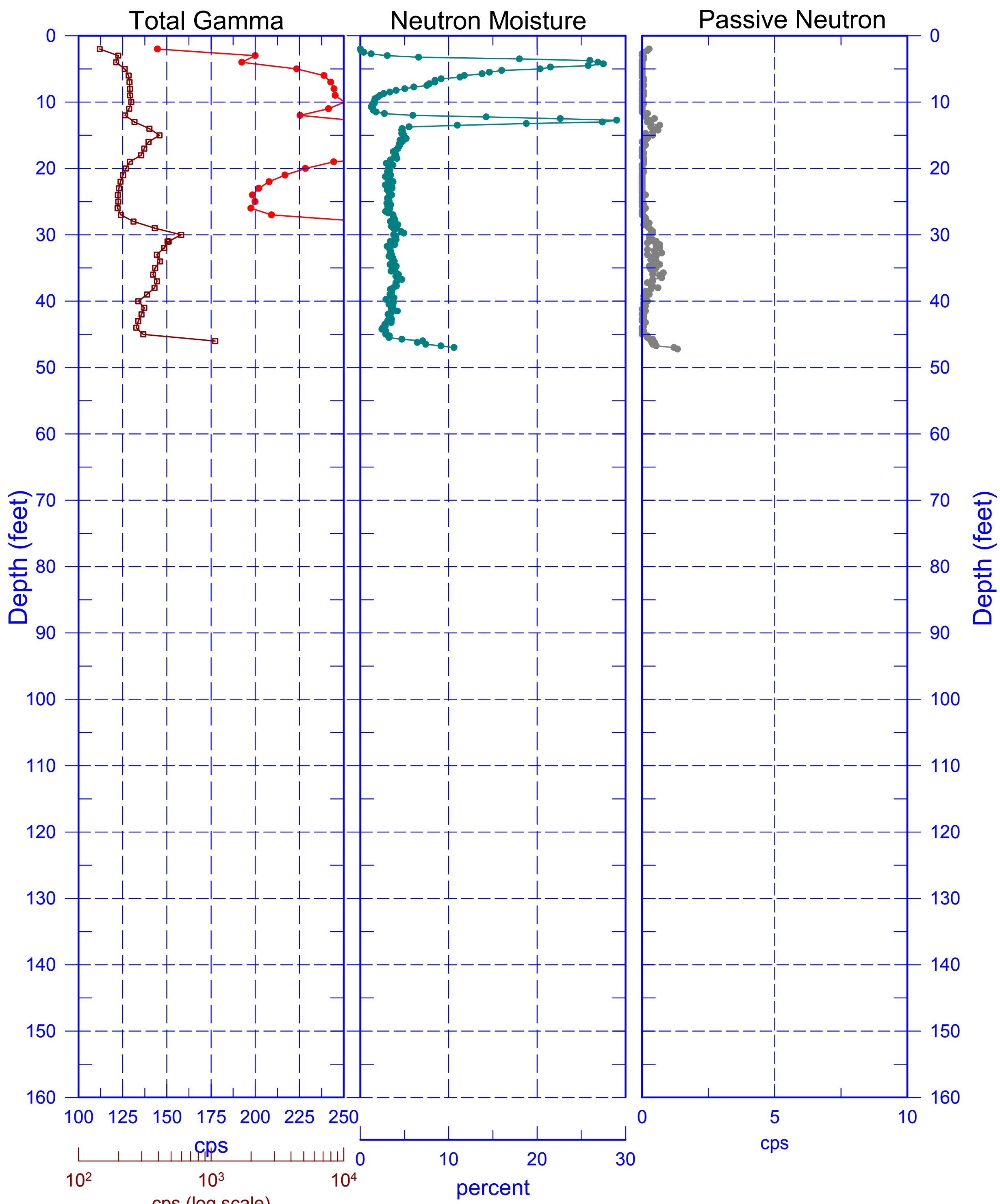
Zero Reference = Top of Casing

299-W18-173 (A7655) Combination Plot



Zero Reference = Top of Casing

299-W18-173 (A7655)
Total Gamma, Neutron Moisture & Passive Neutron



Zero reference = Top of Casing

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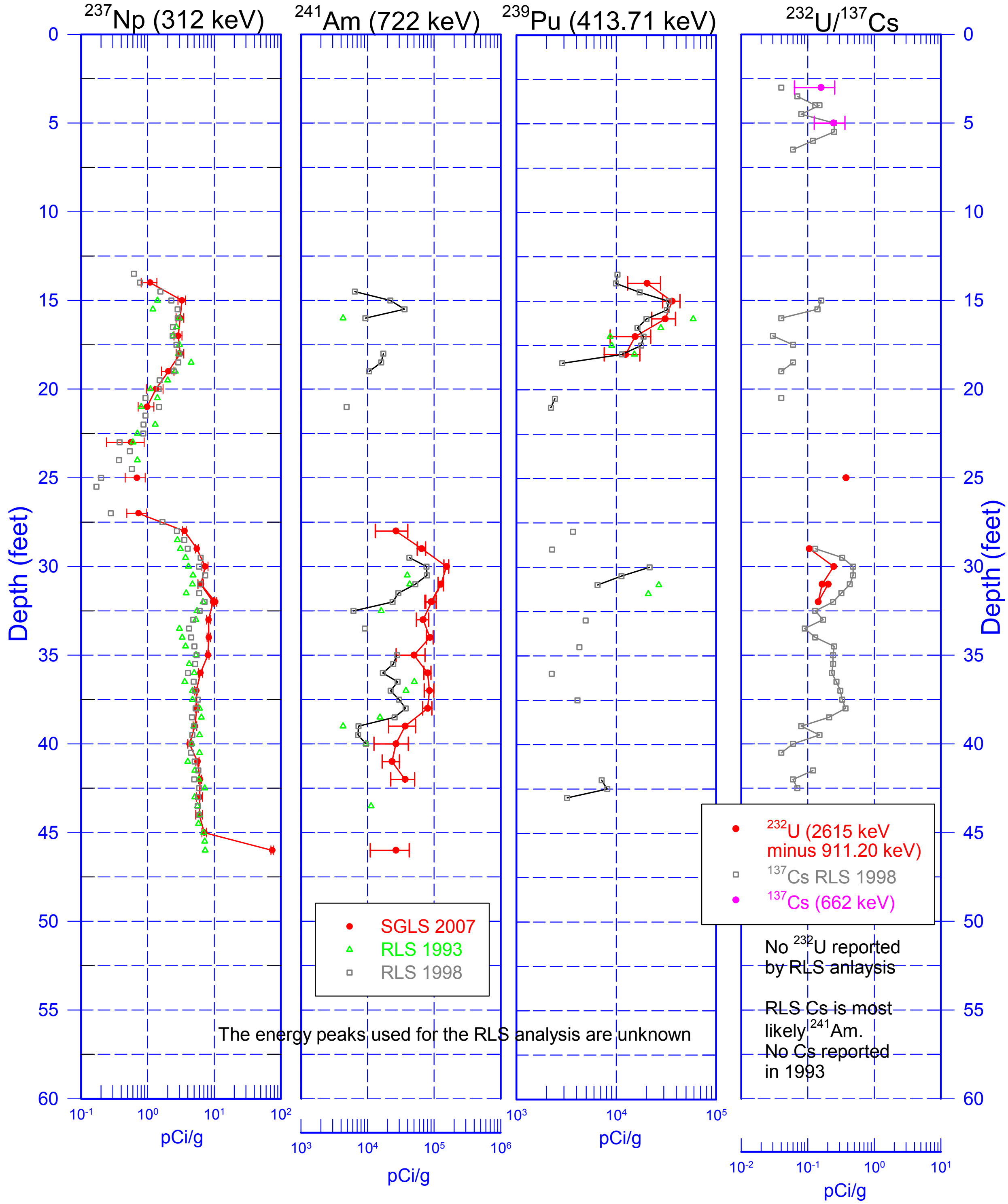
SGLS/RLS Comparison of Manmade Radionuclides



Zero Reference = Top of Casing

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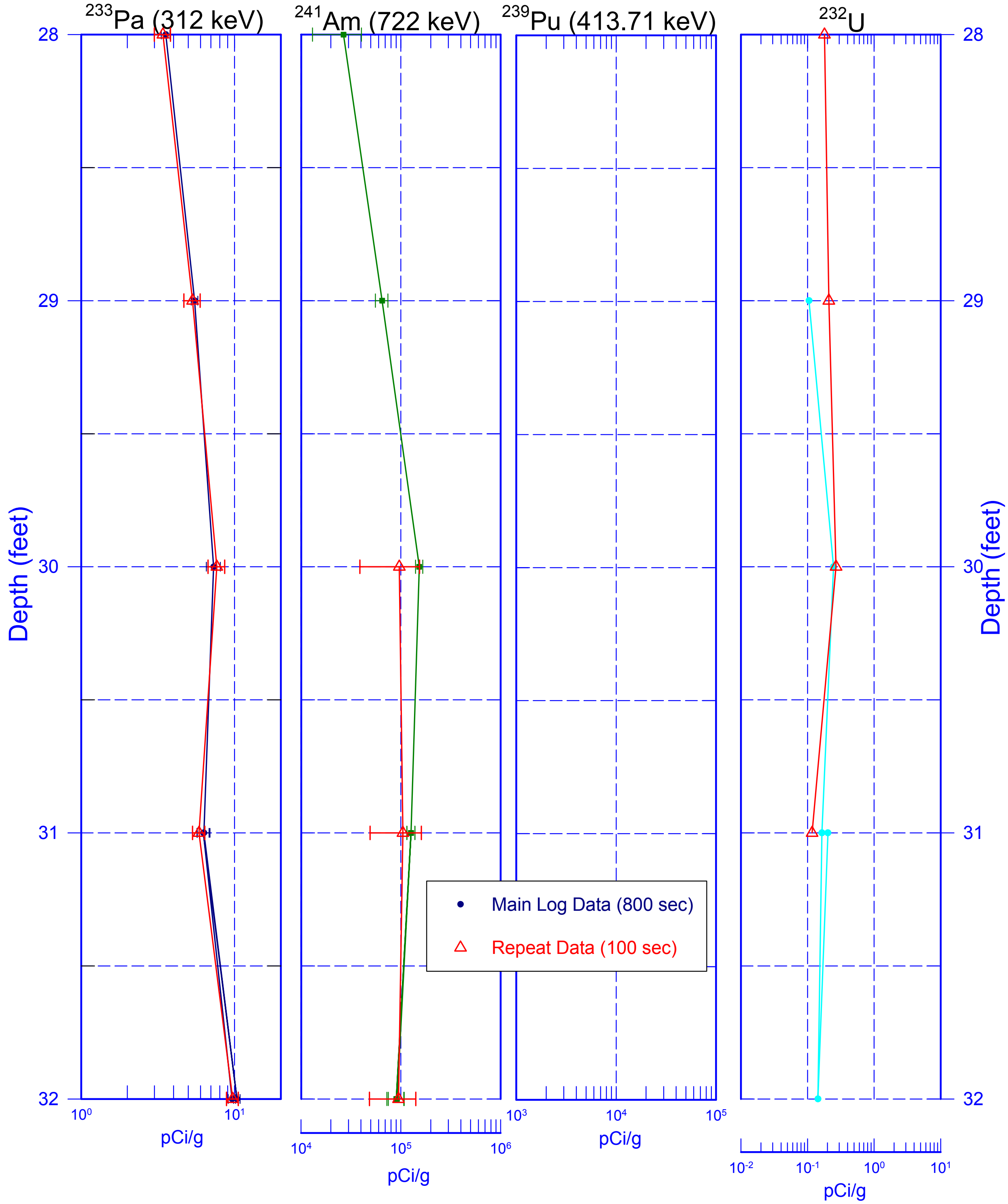
Repeat of Manmade Radionuclides



Zero Reference = Top of Casing

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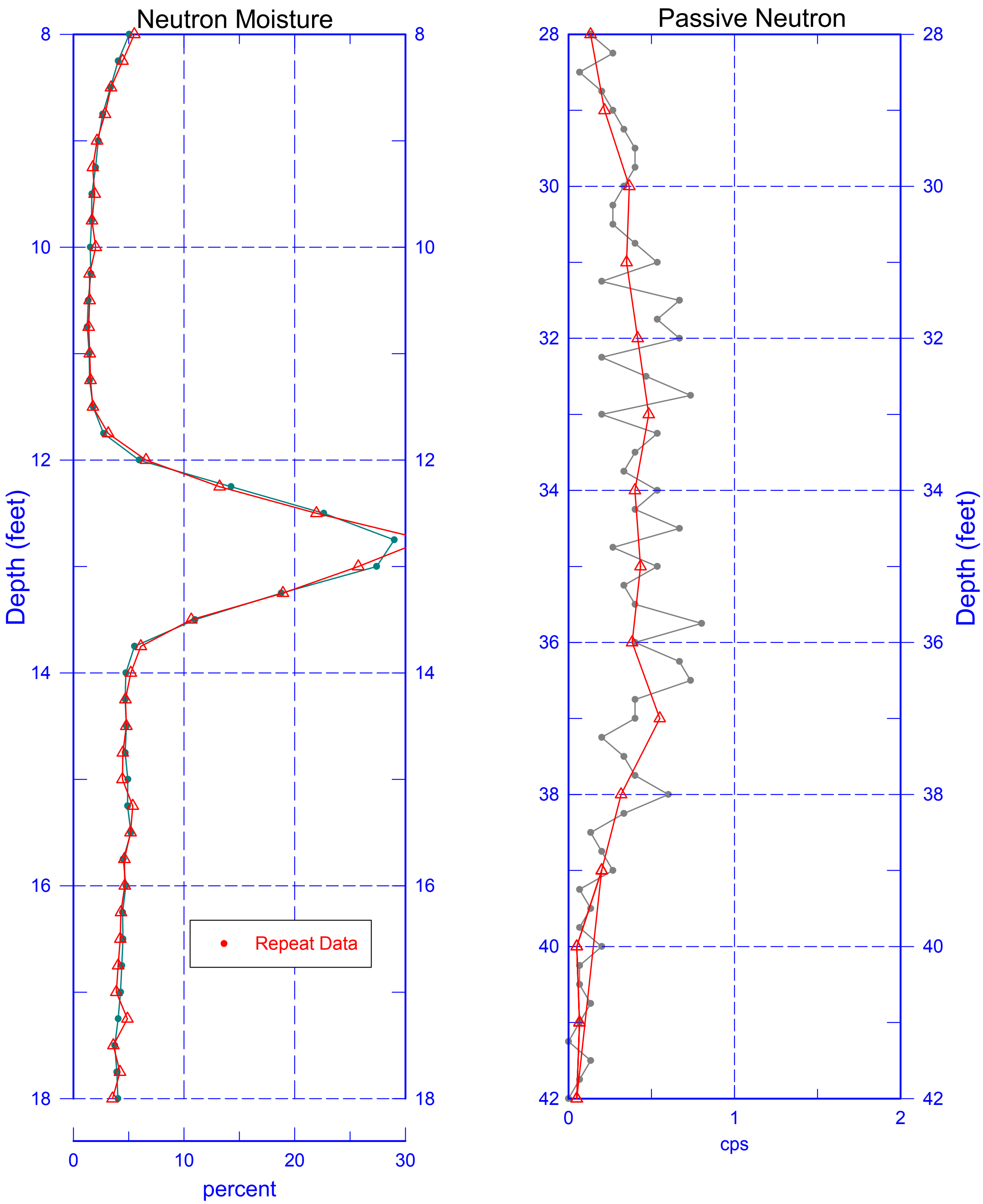
299-W18-173 (A7655)
Repeat for Neutron Moisture & Passive Neutron



Zero reference = Top of Casing